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PHYSICAL, CHEMICAL AND BIOLOGICAL ASPECTS OF HUMAN IMPACTS ON URBAN SOILS OF SZEGED (SE HUNGARY)

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Abstract

Urban soils have generally suffered significant alteration both regarding their physical, chemical, as well as biological properties. Soil samples were taken at 25 sites from horizons of soil profiles located in the downtown and surroundings of Szeged in order to examine diagnostic properties different from natural soils (artefacts, humus content, quality of organic matter, pH (H_2O, KCl), carbonate content, nitrogen content). Furthermore, topsoils were taken nearby 9 profiles to survey some basic biological properties (i.e. abundance, taxon diversity, dominance, similarity and MGP ratios) of mezofauna elements (Oribatid mites, Collembolans) and their community structure in the three zones (city, suburban, peripheral). The high amount of artefacts, fluctuating humus and nitrogen levels, the poor quality of organic matter, the high and fluctuating carbonate content, the concomitant variance of pH and modified mechanical properties prove that the urban soils of Szeged have been modified by anthropogenic activities. Surprisingly, it seems that the intermediate suburban zone has a more heterogeneous and stable mezofaunal community structure than the other two.

Key words: urban soils, diagnostic properties, Collembolans and Oribatid mites in soils

INTRODUCTION

Urbanization results functional and qualitative changes in natural ecosystems, and alters the ecological balance. Urban ecosystems are heterogeneous formations in which soils, flora and fauna are considerably transformed due to anthropogenic pressure. Urban soils attract more and more attention, as they are one of the key elements of urban ecosystem (Beyer L. et al. 1995). The determination of their properties is of great importance both from the aspect of soil science and human health (Simpson T. 1996). Urban soils are very diverse since on one hand they have characteristics close to those of natural soils, on the other hand they are the result of human activity. Consequently, their physical and chemical properties have suffered significant alteration in contrast to natural soils in the surroundings of human settlements. The specific characteristics of these soils are high alkalinity, stratification, clear evidence of technogenic impacts, soil surface sealing, compaction, mixing of anthropogenic (e.g., brick and mortar debris, garbage, rubble, ashes) and natural materials and an increased content of nutrients and toxic elements (Schleuss U. et al. 1998). Therefore, the original multifunctional character of urban soils is gradually lost, they are no longer capable to fully fulfill the functions of natural soils (Stefanovits P. et al. 1999). On the other hand, the weakening and finally the loss of the original functions opens up the way for the development of new special functions, as the city generally hosts a wide range of human objects (building, parks etc.) and activities (transportation, industrial production, trade, waste management and disposal etc.).

The modified physical and chemical parameters exert an influence on soil organisms. As a result, the biological properties of urban soils also differ from those characterising other managed and natural systems (White C. S. – McDonnell M. J. 1988). A general demand of soil research is to evaluate the effect of human activity by applying biological indicators, as physical and chemical parameters cannot completely describe the quality of urban soil. The study of microarthropod communities (besides microfungi and bacteria) can be a powerful method for assessing soil quality because life cycles of these edaphic animals strictly depend on soil characteristics. In terrestrial ecosystems Oribatid mites and Collembolans are represented by the number of species (Stanton N. L. 1979). They generally account for up to 95% of total the number of microarthropods in grassland and play an important role in decomposing organic materials changing the physical and chemical texture of soils, cycling nutrients, and conserving soil environment (Wallwork J. A. 1983). The close relationship between edaphic invertebrates and their ecological niches in the soil, and the fact that many of them live a rather sedentary life provide a good base for the bioindication of changes in soil properties and the extent of human impact (van Straalen N. M. 1998). In all, Collembolans and Oribatid mites are excellent means for assessing and monitoring soil quality and predicting activity of the soil processes, especially those which occur due to human intervention.

After considering the above-mentioned facts, the major aims of the present study can be summed up as follows:

- to examine the physical and chemical properties different from those of natural soils (e.g. artefacts, organic matter content, quality of organic matter, pH

(H_2O, KCl), carbonate content, nitrogen content, total salt)
- to survey the mezofauna (Oribatid mites, Collembola) of different urban soils

STUDY AREA, MATERIALS AND METHODS

Szeged is a major city with the lowest elevation of 84 m ASL in Hungary. The surface is prevailed by elements of the fluvial systems of the rivers Tisza and Maros composed of active and inactive channels (Marosi S. – Somogyi S. 1990). After the Great Flood of 1879 two major flood protection systems were devised: one was relying on the newly constructed ring of dams embracing the inner core areas, the other is based on an elevation of the original surface via significant infilling of the low-lying areas. The largest thickness of the infill, exceeding 6 m, is recorded in the downtown area in the vicinity of the downtown bridge (Andó M. 1979).

Anthropogenic soil evolution was initiated in the city of Szeged on the following natural soil types: on the right banks of the river Tisza west and north-west of the city high quality Phaeozems developed on a loessy bedrock. The highly compact alluvial bedrock of the region of Újszeged favored the evolution of Fluvisols with different degree of maturity. The southern areas of the city are covered by Gleyosols. While the areas just north-east of Szeged are covered by highly compact Solonetz soils of poor hydrological parameters.

Samples were taken at 25 sites from the identified horizons of the individual soil profiles yielding a total of 127 samples for further study (*Fig. 1, Table 1*). The samples were dried, crushed and sieved through a mesh of 2 mm for further analysis. The artefact content was determined by giving the m/m % of the fraction remaining on the sieve. The pH (H_2O, KCl) was recorded using a digital pH measuring device of Radelkis type. In order to capture the hidden acidity of soils the pH of a KCl soil suspension was also recorded. The organic content was measured after H_2SO_4 digestion in the presence of 0.33 M $K_2Cr_2O_7$. The quality of humus was given by the humus stability coefficient (K value). The total salt content of the soils was determined via recording the electric conductivity of fully saturated soil samples. The carbonate content of dry soil samples given in percentage was determined via Scheibler-type calcimetry. The nitrogen content was measured using nitrogen distilling device type Gerhardt Vapodest 20. The mechanical composition was determined by the yarn test of Arany (Buzás I. et al. 1988).

According to the investigations of Szemerey (2004), the presence of the mezofauna in the soil is the greatest during spring and autumn. Consequently, soil samples were taken in October 2006, nearby 9 profiles (No. 1, 2, 4, 9, 11, 15, 16, 18, 22), representing three zones (city,

Fig. 1 Location of sampling sites on a map of the city of Szeged

Table 1 Characteristics of the sample sites

Profiles	*No. of soil horizons*	*Bedrock*	*Morphology*	*Perched groundwater depth (cm)*	*Landuse (2005)*	*Vegetation cover (2005)*
1.	6	infill	plain	> 200	Built-in area	-
2.	4	loess	plain	> 75	Meadow	Lolium perenne, Taraxacum officinale
3.	9	loess	plain	> 125	Bicycle road	Taraxacum officinale, Elymus repens, Lolium perenne,
4.	6	infill	depression	> 80	Abandoned area	Rosa canina, Phragmites australis, Poa trivialis, Arrhenatherum elatius
5.	5	infill	plain	> 140	Sidewalk	-
6.	6	infill	plain	> 150	Built-in area	Elymus repens, Ambrosia artemisiifolia, Erigeron canadensis, Chenopodium album,
7.	4	loess	plain	> 180	Built-in area	-
8.	8	infill	slope	> 180	Meadow	Taraxacum officinale, Elymus repens
9.	4	infill	plain	> 155	Built-in area	-
10.	5	mud	plain	> 180	Built-in area	-
11.	6	infill	plain	> 180	Built-in area	-
12.	7	loess	plain	150	Plot	Ambrosia artemisiifolia, Elymus repens, Polygonum aviculare
13.	5	infill	plain	> 150	Built-in area	-
14.	5	loess	plain	> 170	Common	Artemisia vulgaris, Cichorium intybus, Achillea millefolium
15.	8	loess	plain	> 200	Dirt road	Cichorium intybus, Taraxacum officinale
16.	3	loess	plain	>130	Arable land	Daucus carota, Petroselium crispum
17.	3	loess	plain	>95	Arable land	Medicago sativa
18.	2	mud	depression	80	Meadow	Lythrum salicaria, Bolboschoenus maritimus, Carex vulpina
19.	2	mud	depression	50	Arable land	Zea mays
20.	5	loess	plain	>135	Orchard	Brassica oleracea, Pisum sativum
21.	4	loess	plain	100	Orchard	Solanum lycopersicum, Capsicum anruum
22.	10	infill	plain	>180	Park	Taraxacum officinale, Lolium perenne
23.	4	loess	plain	>120	Orchard	Brassica oleracea, Allium cepa
24.	3	mud	plain	>85	Pasture	Festuca pseudovina, Artemisia santonicum, Limonium gmelini
25.	3	mud	depression	>80	Pasture	Potentilla reptans, Phragmites australis

suburban, peripheral zone). One sample (No. 26) was not originating from the close vicinity of a profile, but it was taken from under a peripheral zone deciduous forest. For the analysis of the soil fauna top soil (0-5cm) samples were applied, which were gained from two 30x30cm quadrates. The extraction of the tiny soil microarthropods in isopropyl-alcohol was carried out using a modified Balogh extractor within 5-6 hours after sample collection (Hoblyák J. 1978). The samples were treated with saturated NaCl suspension (Móczár L. 1962.) and filtered with vacuum sieve. The extracted animals were sorted under a binocular stereomicroscope. Adult Oribatid mites were identified in lactic acid to a genus level, and if it was possible species were also determined, using 100x, 200 x magnifications. The taxonomy of Oribatid mites is well studied, thus the identification of genera can be made confidently with the available identification books (Balogh J. – Mahunka S. 1980, Balogh J. – Balogh P. 1992, Weigmann G. 2006). The Collembolans were identified to families under binocular stereomicroscope following Bellinger's online identification database (1996-2007) and Bährmann's identification book (Bährmann R. 2000). The community structure of Oribatid mites was determined on the basis of *abundance*. Abundance stands for the number of adult individuals in each taxa, and it provides data on the distribution of mites in a given amount of soil sample. Nymphas were not counted since their identification has not been clearly defined yet.

The *diversity* of mesofaunal communities was also determined, meaning that the number of taxa (genera) was counted in a given amount of soil sample. The structure of Oribatid mite communities was described with the *genus dominance index,* calculated with the help of the following formula (Hoblyák J. 1978):

$$D = s/S*100$$

(s: The number of individuals belonging to a given genus in the sample; S: The summed number of individuals of all genera in the sample)

To compare the genus composition of Oribatid mite communities, located in the city, suburban and peripheral zones, *the Sørensen index* was used (Mátyás C. 1996). The value of the index ranges between 0 and 1, depending on the presence of common taxa (here genera).

$$Cs=2*c/(A+B)$$

(c: the number of common genera; A, B: all genera in the given samples)

Furthermore, an MGP analysis was also applied in order to evaluate the stability of the Oribatid mite community in the 3 urban zones. This method is based on the proportion of the three major taxonomic units (Macropylina: M, Gymnonota: G and Poronota: P) (Balogh J. 1972). All of the three major taxonomic units have distinct ecomorphological features and their proportion is different at the various stages of association development (Aoki J. 1983). The criteria for the establishment of MGP types are as follows:

- >50% individual number of Macropylina to total individual number (or total species number)→ M type
- >50% individual number of Gymnonota to total individual number (or total species number)→ G type
- >50% individual number of Poronota to total individual number (or total species number)→ P type
- >20% and <50% of each 3 groups to total individual number (or total species number)→ O type
- >20% and <50% of each M and G groups, and <20% of P group to total individual number (or total species number)→ MG type
- >20% and <50% of each M and P groups, and <20% of G group to total individual number (or total species number)→ MP type
- >20% and <50% of each G and P groups, and <20% of M group to total individual number (or total species number)→ GP type

The MGP-I analysis is based on the number of species, whereas the MGP-II is based on the number of individuals using the above criteria. Collembolans were classified into 4 superfamilies each corresponding to a major ecomorphological group (Parisi V. et al. 2003). The abundance of each superfamily was determined in the three different urban zones.

RESULTS AND DISCUSSION

Evaluation of physical and chemical properties

First of all, those physical, chemical properties of Szeged soils were examined, which can indicate human impact. The examined properties were chosen from the diagnostic properties of urban soils given by Hollis (1992). The main question was whether these physical and chemical properties were able to indicate urban influence on the soils of Szeged. On the other hand, we also assessed the degree and way, how the good indicators reflect the anthropogenic effects on urban soils.

The average *artefact content* of soil profiles ranged between 0.0-23.7%, with a minimum value of 0.0%, and a maximum value of 63.0%. 11 out of 25 profiles contained no artefact at all. Some of these profiles (No. 16, 17, 18, 19, 24, 25), originating from the most peripheral parts of the city, represented original genetic soil types, thus the lack of artefacts was due to insignificant urban activity. This parameter was not present in further 3 profiles, originating from small orchards situated on the outskirts (No. 20, 21, 23). Profiles with very few (0-2%) or few artefacts (2-5%) were either found in the surroundings of the city, where the thickness of the infill is relatively negligible (profiles No. 10, 12, 14, 15); or in the downtown where the infill might be considerable, but of higher quality and lack of artefacts (profiles 1, 5, 13). To the category common (5-15%) the profiles (No. 3, 8, 9, 11) with either partly or fully containing infill can be placed. Profiles containing a large amount of artefact (15-40%) were entirely composed of artificial infill. Thus, the minimum, maximum values and the standard deviations were also striking in case of these profiles (No. 4, 6, 22). Consequently, the amount of artefacts is not decreasing towards the city margins, because this property changes rather due to "point" factors and not regional ones (FAO 2006).

The *mechanical soil types* of Fluvisol, Gleyosol, Solonetz soils are clay, heavy clay, whereas in case of Phaeozem soil type clayey mud is typical. In some profiles (No. 7, 14), located in the surroundings of the city, the original soil horizons could remain. Towards the margins of the town, mixed profiles (No. 2, 3, 8, 12, 15), composed of landfill and original buried soil horizons, were also found. The horizons representing infill were dominated by sand, sandy mud and mud, while those preserving the original conditions by clayey mud. In the profiles composed of purely artificial infill (No. 1, 4, 6, 9, 11, 22) also sand, sandy mud and mud were dominant. The abrupt textural change was mostly characteristic of artificial horizons in contrast to the gradual textural change of natural horizons. This is also an excellent indicator of human influence.

The average *humus content* of the profiles was between 0.6 and 2.3%, with a maximum of 3.7% and a minimum of 0.0%. If considering the average values, only one profile (No. 18) developed on a natural Gleyosol, showed normal humus content (2-4%). Certain profiles were classified into the category of extremely poor humus content (<1%), while the majority fell into the category of poor humus content (1-2%). To the category extremely poor profiles No. 1 and 5 with fully containing infill in the downtown area and the profiles (No.

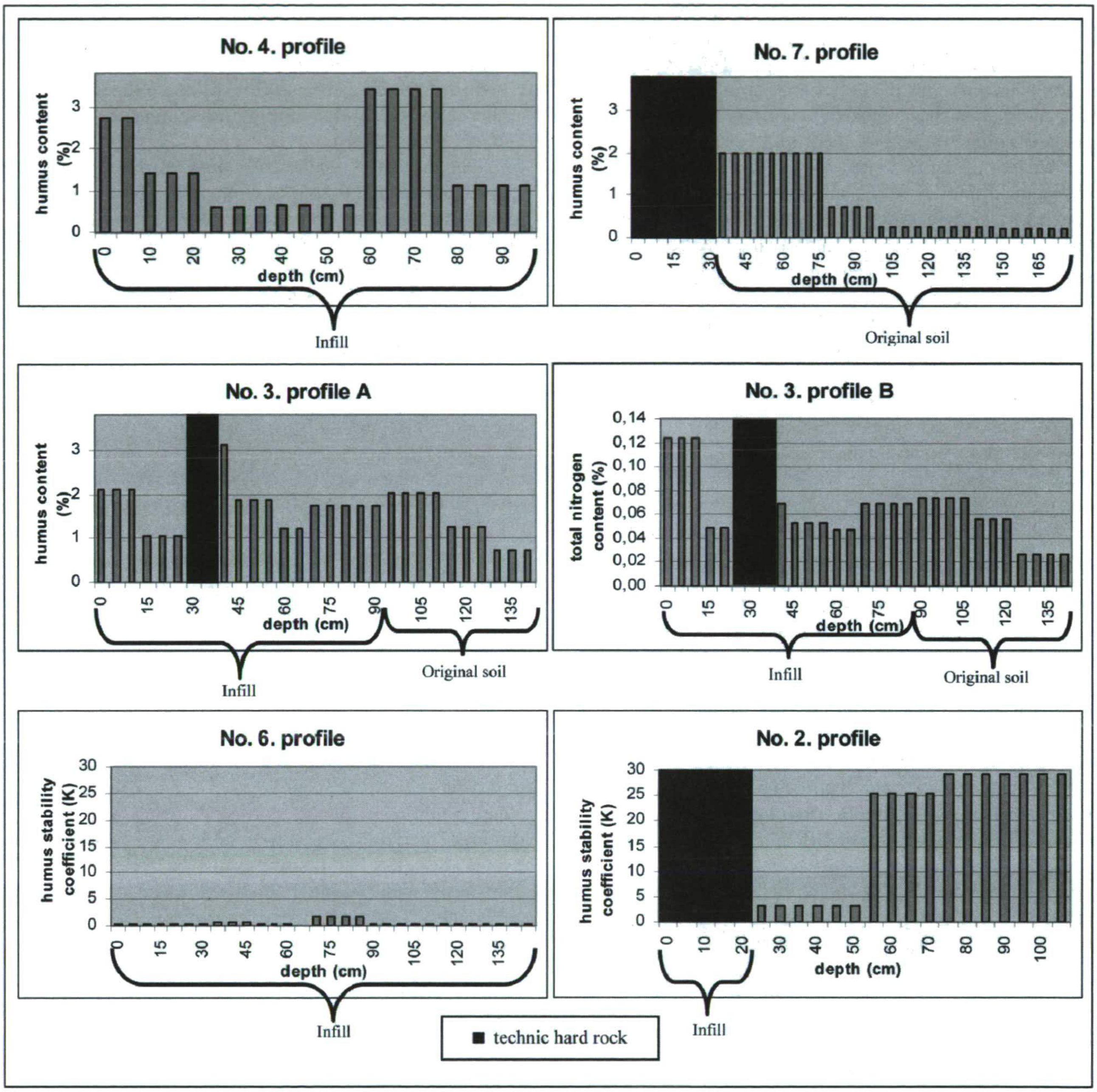

Fig. 2 The humus content and nitrogen content of some studied profiles

2, 7, 12, 14) with slight amount of infill on outskirts can be placed. The remaining 17 natural and artificial profiles fell into the category of poor humus content. It might be more important to study the distribution of this parameter along individual profiles, as it can clearly show the degree of human impact. Along a natural profile, humus content is congruent with original genetic soil type: it shows generally gradual downward decrease towards the bedrock (Lorenz K. – Kandeler E. 2005) (*Fig. 2*, profile No. 7). Conversely, the humus content tends to display an irregular fluctuation in those profiles which are fully made up of artificial infill, depending on the humus content of the layers utilized (*Fig. 2*, profile No. 4). However, we also found mixed profiles embedding considerable amount of infill material and buried soil horizons as well. In case of these latter ones, the tendency for the humus content is congruent with that of natural soils from the appearance of the A horizon of the original buried soil (*Fig. 2*, profile No. 3/A).

The significant alteration of physical, chemical and biological properties of urban soils influences the nitrogen cycle of these soils (Beyer L. et al. 1995, Craul P. J. 1999). Thus, besides the determination of humus content as a complementary analysis the *total nitrogen content* of the soil samples was also measured. The average nitrogen content of the profiles was between 0.02 and 0.11%, with a maximum of 0.19% and a minimum of 0.0%. The amount of nitrogen in soils is primarily determined by the type and intensity of microbial activities. Consequently, the highest nitrogen values are recorded in those horizons where biological activity is the strongest and the largest amount of humus is produced (Stefanovits P. et al. 1999). As a matter of fact, the distribution of nitrogen along the studied profiles showed similar tendencies as in the case of humus. Thus, infilled horizons represented fluctuating nitrogen content, while natural horizons corresponded to the characteristic of the genetic soil types (*Fig. 2*, profile No. 3/B). Beside the distribution of nitrogen along a profile, it is also important to evaluate quantitative differences: most profiles fell into the category of extremely poor nitrogen content (<0,05%), profiles with higher amount of humus were classified into the category of poor nitrogen content (0,05-0,10%).

From the practical side it is important to know the ratio of well-humified, condense humus components composed of larger molecules, serving as primary agents in establishing the structure of the soil as well as its nutrition content, to those organic components which are not bond to calcium and less humified. This ratio is clearly depicted by the *K value*. The average K values were between 0.3-14.4 with a minimum of 0.0, a maximum of 29.2, indicating significant differences among profiles. Since the urban soils in the downtown of Szeged are "young" soils in contrast to the natural soils in the surroundings of the city, they have not had enough time for the formation of good quality humus yet. Consequently, the horizons with considerable amount of artificial infill were characterized by very low K values, indicating the prevalence of raw humus components, i.e. fulvic acids not yet subjected to humification (*Fig. 2*, profile No. 6). However, those mixed profiles containing remains of the original natural soil horizons as well had higher K values referring to the dominance of high-quality humic acids in these levels (*Fig. 2*, profile No. 2).

The average *carbonate content* of soil profiles ranged between 0.9-25.6%, with a minimum value of 0.08% and a maximum value of 40.2%. Considering the profile average values, one can be placed into the category extremely calcareous (>25%). Thirteen heterogonous profiles can be classified into the category highly calcareous (10-25%). Profile No. 17, representing this type, is located in the surroundings of the city on Phaeozem as original genetic soil type. Profiles No. 20 and 21 are located in orchards of the outskirts and developed on Phaeozem soils free of infill. In case of some further profiles (e.g. profiles No. 7, 12, 14) of highly calcareous character the loessy bedrock was the most important source of the high carbonate content.

These profiles are located in the suburban area, in surroundings of the city on a Phaeozem and represent a mixture of natural soil horizons and artificial infill. In such profiles there was a gradual downward increase in the carbonate content towards the bedrock from the first natural soil horizon (*Fig. 3*, profile No. 12). The reason for this is the leaching of carbonate phases from the upper soil horizons and the accumulation of these in the underlying layers or the bedrock itself. The other remaining half of the highly calcareous profiles were composed of fully artificial infill. Here either the considerable amount of carbonate-rich artefacts or the carbonate rich infill horizons were responsible (*Fig. 3*, profile No. 1). On the other hand, some profiles (No. 8, 9, 11, 13) containing artificial infill could still have lower carbonate content. These and the natural profiles (e.g. No. 16, 18, 19, 24) with relatively lower carbonate values formed the category of moderately calcareous soils (2-10%). Two profiles representing Fluvisol fell into the

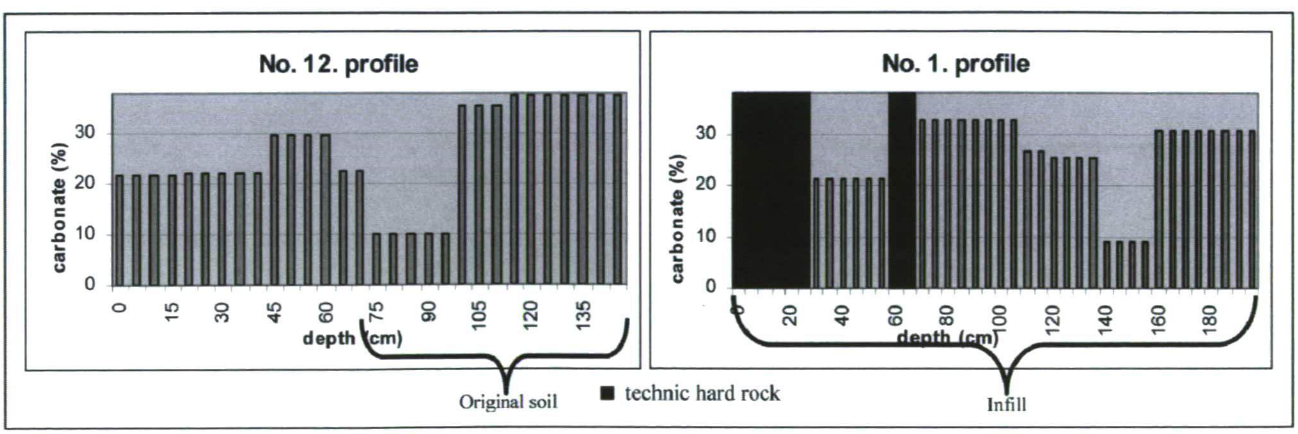

Fig. 3 The carbonate content of some studied profiles

Table 2 The dominant and characteristic genera of Oribatid mites at different urban zones. (Those genera are presented the proportion of which was above 10%)

Urban zone	*City*				*Suburban*			*Natural*		
Sample No.	*1*	*11*	*9*	*22*	*2*	*4*	*15*	*18*	*16*	*19*
Dominant genus	Rhysotritia 40.7%			Rhysotritia 90%	Tectocepheus 60%	Rhysotritia 41%	Zygoribatula 51.5%	Tectocepheus 17.4%	Eupelops 67.5%	Tectocepheus 60.8%
Characteristic genus	Scheloribates 34.6					Scheloribates 33%	Ceratozetes 28.1%	Eupelops 12.9%	Tectocepheus 31.1%	

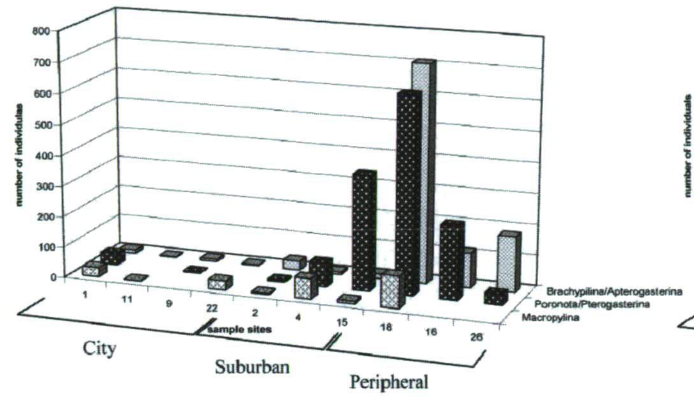

Fig. 4 The number of oribatid mites for major taxonomic groups at each sample site

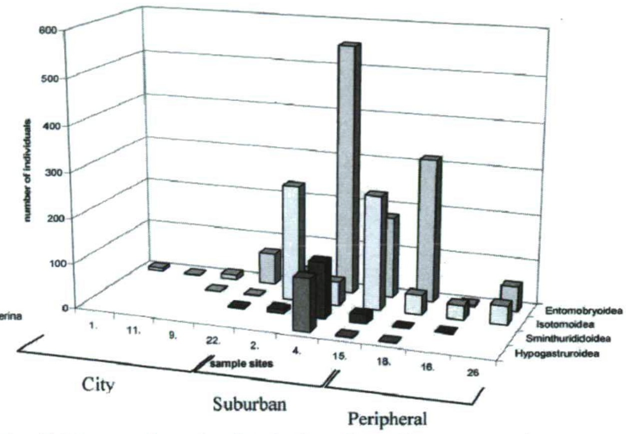

Fig. 5 The number of collembolans for major taxonomic groups at each sample site

category of slightly calcareous soils (0-2%). As a result of regular flooding, only the uppermost horizons of these profiles contained aerated carbonate (FAO, 2006).

The averages of the *pH*(H_2O) were between 7.7-9.7 with a minimum of 7.3, a maximum of 10.0. The *pH(KCl)* averages were between 6.9 and 8.7, with a minimum of 6.7, a maximum of 9.0. Based on average values of the pH(H_2O), only profile No. 24 was classified into the category of strongly alkalescent soil. All other profiles fell on the transitional line between categories of slightly alkaline and alkaline soils. The close correlation between recorded pH values and carbonate content is rather obvious: the high carbonate content results in high pH values. Thus, observed fluctuations of the carbonate content within the studied profiles were congruent with the pattern observed in the pH values. Those profiles were alkaline which were located on Phaeozem containing infill material with considerable carbonate content and buried soil horizons with very significant carbonate content. The loessy bedrock of buried soils could increase further the pH average.

Investigation of mezofauna (Oribatid mites and Collembolans)

The concept that the higher soil quality is the more microarthropod groups identified had been proposed (Parisi V. et al. 2003), and even it was formulated as QBS (i.e. "Qualità Biologica del Suolo", namely Biological Quality of Soil). We followed this concept in the case of our study, except for the fact that we analysed only the most abundant mezofaunal elements: Oribatida („box mites") and Collembola (springtails). Statistical analysis was omitted, since it requires repeated samplings for at least 1-2 years. The gained results provide a rapid and robust tool for soil science to evaluate the biological activity of urban soils. Oribatid mites and Collembolans were found at each sampling point, but the numbers of individuals belonging to the different taxa were very different.

The collected 2744 adult Oribatid mites belonged to 54 taxa. 40 of the 54 taxa were identified to species and 14 to genus level. Approximately 10% of the Hungarian Oribatid fauna were recorded in the samples of Szeged and its peripheral belt. This number, compared to the values of a natural deciduous forest, rich in Oribatid mites, is not too low. Macropylina, Brachypilina (Gymnonota) and Brachypilina (Poronota) gave 12.9%, 40.7% and 46.4% of the identified adult mites, respectively.

In the *city zone* 8 genera were found, all with a very low abundance (52 sp./m^2). The number of city zone genera was only 15% of the total genus number found in this study. Although this zone is the most disturbed and polluted, a very rare Mediterranean species (*Lohmannia turcmenica*, Bulanova-Zachvatkina, 1960), a special wetsoil mite (*Scapheremaeus palustris*, Sellnick, 1924) and a yet undefined Oppiinae species were found here.

These rare species did not appear at other parts of the study area. Due to the low number of specimens, only two samples (No. 1, 22) were suitable for calculating the dominance index. In this zone Rhysotritia was the absolute dominant (90% and 40.7%) and Scheloribates was the characteristic genus (*Table 2*).

The *suburban zone* was unambiguously different in terms of specimen density and taxon diversity (*Fig. 4*). Compared to the city zone in this intermediate or transitional area twice as many genera (20) were identified, and the values of abundance were an order of magnitude higher (657 sp./m^2). The sites in this zone community structure of Oribatid mites were very heterogeneous. Heterogeneity is well signed by the fact that each site differed in terms of both the dominant and characteristic genera (*Table 2*). Community struc-tures indicate a transition between those of the city and the peripheral zone. This is also suggested by the fact that both the typical genera of the city and the peripheral zone were represented here by high individual numbers. Towards the peripheral zone taxon diversity gradually increased (*Fig. 6*). Members of the Macropylina group (Rhysotritia, Eniochthonius, Nothrus) appear with relatively high individual numbers, and different kinds of Zygoribatula and Oppiidae (Dissorrhina, Neotrichoppia, Oppiella, Oppia, Ramusella) genera did also occur. The number of genera (Eniochthonius, Belba, Dorycranosus, Suctobelba) recorded exclusively in this zone was nearly as much as in the peripheral zone.

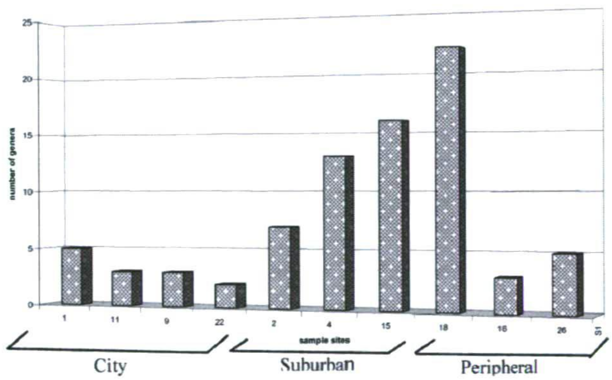

Fig. 6 The number of genera of Oribatid mites at each sample

The Oribatid mite density in the *peripheral zone* with close to natural habitats was much higher than in the former zones. In fact, it is an order of magnitude higher (2252 sp. /m^2) than the density determined in the suburban zone. This zone had the highest number of taxa, 44% of the total genus number. However, this is not a dramatic difference compared to the suburban zone. The highest number of individuals, 53% of the total number, was also identified here.

It is well visible on *Fig. 4* that the 3 peripheral zone sites showed great heterogeneity both in terms of specimen number and community structure. Note that the abundance and heterogeneity indices of sample No. 16 and 26 were significantly lower than those of sample No. 18. Soil type, the absence of vegetation cover and the type of agricultural cultivation could be responsible for the development of the poor community structure similar to those in the city. In case of sampling site No. 16 perhaps low moisture content of the sandy topsoil and sparse vegetation cover provided unfavourable conditions for Oribatid mites. On the contrary, the dense vegetation cover at sample No. 18 was much more preferable for these animals. Nevertheless, samples of this zone having lower genus number were still more diverse in terms of Poronota and Brachypilina (Poronota) groups than any other city zone samples. Depending on the type of habitat Eupelops and Tectocepheus were the dominant genera (*Table 2*).

The similarity analysis based on the Sørensen index showed that there were more common genera in terms of the suburban and the peripheral zone (C_S=0.50) than in case the city and the suburban (C_S=0.34) or the city and the peripheral (C_S=0.26) zones. All of these reflect the extreme character of city zone. The results of MGP-I and MGP-II analyses can be seen on *Fig. 7* and *8*. According to the MGP-I analysis, the patterns of the peripheral and suburban zones were similar, while that of the city zone differed from both. The genera based M:G:P ratio was 1:2:1 in the city and 1:2:2 in both the intermediate and peripheral zone (*Fig. 7*). In general, the intermediate and peripheral zones were GP-type, while the city zone was O-type. According to the MGP-II analysis, the above ratio was 1:1:1; 1:8:1 and 1:4:4 in the city, suburban and peripheral zones, respectively (*Fig. 8*).

Surprisingly, the proportion of M and G groups was relatively high in the city zone. Previously, such community structure was primarily found in stable closed canopy forests (Aoki J. 1983). However, due to low density values the above proportions have to be handled with care. The abundance and proportion of group G in the intermediate zone turned to be very high during the MGP-II analysis, this zone was characterized thus as G-type. The pattern of the peripheral zone was similar to the results received during the MGP-I analysis, so this area can be considered GP-type.

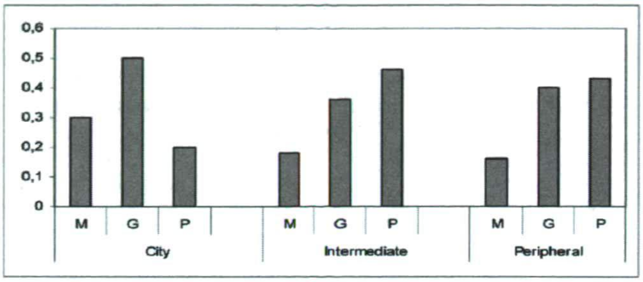

Fig. 7 MGP-I analysis: MGP ratios in the 3 different zones, based on number of genera

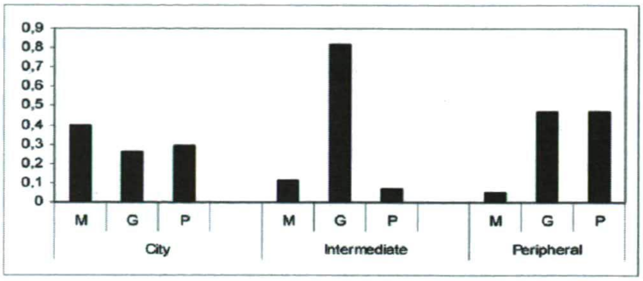

Fig. 8 MGP-II analysis: MGP ratios in the 3 different zones, based on the number of individuals

Our results from the city zone seemingly contradict the hypothesis described by Lee et al. (1999). According to their theory, the M:G proportion of Oribatid mites is considerably lower in a city environment than in close to natural areas, while the high proportion of the P group is due to the fact that its members are previously described as pioneer species. One of the reasons in the background of our different results could be the low number of individuals in the city zone, which might provide a distorted view on proportional values. Besides, the *Rhysotritia ardua* (member of the special group of Ptychoid within Macropylina) seemed to be more sensitive than it had been expected before the MGP analysis. Thus, in accordance with the opinion of its author, the MGP method requires further elaboration to provide a precise tool for the ecomorphological classification of Oribatid mites. 2063 Collembolan individuals were identified and classified into 4 superfamilies: Entomobryoidea, Isotomoidea, Sminthuridoidea, Hypogastruroidea. Most of Collembolans represented the Entomobryoidea superfamily, the second most abundant group was Isotomoidea with almost third of the total individual number (*Fig. 9*). The two remaining groups had low representation, and altogether gave 13% of the total number. 77% of the Collembolans originated from sampling sites of the suburban zone. The peripheral and city zone provided only 18% and 5% of the Collembolans, respectively. The suburban zone was especially interesting as each ecomorphological group had the highest individual number here (*Fig. 5*). Note that the Entomobryoidea group was much more common than the others, since its members were identified at all sampling sites. The most sensitive group was Hypogastruroidea, the members of which were collected in large numbers only in the suburban zone (sample No. 4). The presence of all the four ecomorphological groups signed higher diversity, which referred to less disturbance in this zone. Before the mezofauna investigation our basic hypothesis was that the number and abundance of taxa would increase from the city towards the semi-natural habitats of the peripheral zone. In accordance with the above, the lowest abundance values were experienced in the city zone, being an order of magnitude lower than elsewhere. There was a great difference between the taxon diversity of Oribatid mites in the city and the suburban zone, while the taxon diversity in the suburban and peripheral zones was similar. The low abundance in the city can be related to high air and soil pollution, habitat isolation and low moisture content of the soil (Weigmann G. – Kratz W. 1986). However, the mezofauna in the more polluted and disturbed habitats of cities are obviously more random (Erhard C. – Szeptycki A. 2002). That could be the reason for finding 3 peculiar species in the city zone of Szeged. The diversity of dominant species was the greatest in the suburban zone. This fact and high individual numbers suggest that the intermediate zone is a relatively good habitat. Based on the dominant Oribatid mite species of the suburban zone, the transition between the barren city and heterogonous peripheral zones could be considered continuous. The high individual and genus number of Gymnonota and Poronota taxa in the suburban and peripheral zones suggested a more stable Oribatid mite community. The abundance pattern of Collembolans corresponded well to that of Oribatid mites. The diversity and abundance of Collembolans were the lowest in the city zone. It seems as if Collembolans accumulate rather in suburban soils in contrast to Oribatid mites, which are more abundant in peripheral soils.

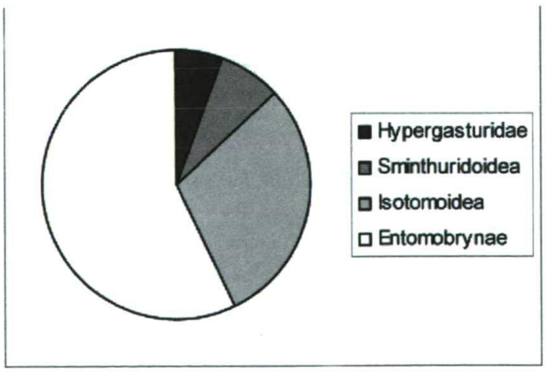

Fig. 9 Proportion of the major Collembolan groups of all samples

CONCLUSION

All the soil parameters mentioned so far are excellent markers of human influence in urban soils. This can be seen either in a change in their recorded concentration values or the alteration of their vertical distribution in the profiles. An elevated amount of artefacts, the fluctuating humus and nitrogen levels, the poor quality of the humic material, the high and fluctuating carbonate content and a concomitant variance in the pH, the modified mechanical properties all refer to a soil affected and transformed by human activities.

Beside the physical and chemical properties of the soil, the biological indicators were also analyzed. The diversity of soil mezofauna communities was expressed with "genus diversity". To analyze the similarity of Oribatid mite genus composition between two urban regions the Sørensen index was applied (Mátyás C. 1996). Identifications to more general levels can be declared an efficient way of assessing biodiversity rapidly and it is therefore likely to be used by land-use planners and urban environmental consultants who are concerned with the rapid changes in the biota as a result of urbanization (McIntyreet N. E. et al. 2001, Parisi V. et al. 2003). For that reason, we have identified the selected groups to family and genus level. Our results greatly support those of a former investigation by Magura T. et al. (2006) in which they found that intermediate, transitional areas between the city and the peripheries show a greater diversity than the later two. It seems that this intermediate zone is stable and heterogeneous enough to constantly provide the species for the city and peripheral areas. The concentric structure of Szeged is also important in ensuring a gradual transition between the city and the peripheral areas. Since there is no contiguous industrial zone, the intermediate area between the city and the peripheries can be a significant buffer and refugium for soil microarthropods.

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